TRUCK HAULAGE AT THE NATIONAL LEAD CO. OPEN-CUT ILMENITE-MAGNETITE MINE TAHAWUS, N. Y.

BY ROBERT S. SANFORD

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CONTENTS

	Page
Introduction and summary	1
Acknowledgments	2
Location	2
History	2
Physical features and climate	2
Character of ore	3
Mining methods	3
Truck haulage	4
Tires	10
Maintenance	13
Bibliography	14

ILLUSTRATIONS

Fig.		Follows page
1.	Location map	2
2.	Open-cut mine	2
3.	The concentrator	2
4.	View of shovels and drills	4
5.	Loading a 22-ton ore truck	4
6.	Hauling ore on a smooth mine road	4
7.	Ore truck dumping at crusher	4
8.	Steel plate hung between dual tires	10
9.	Safety chains, used when tires are being inflated for the first time	10
10.	Tachograph and chart	14

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INTRODUCTION AND SUMMARY

This paper is one of a series recently undertaken by the Mining Branch, Bureau of Mines, College Park, Md., to describe current practice in hauling ore and waste by truck at various mines.

Heavy-duty ore trucks are replacing railroads at many large open-cut mines and even at a few underground mines. Recently a few mines have been equipped with trucks for transporting ore to a central point, from which conveyor belts move the ore out of the mine. This paper deals only with truck haulage methods and costs.

The requirements for efficient low-cost truck haulage are good trucks designed for heavy loads, adequate truck maintenance, smooth roads, and well-trained truck drivers.

A correct balance must be maintained between the primary crusher capacity, the number of shovels loading ore, and the number of trucks hauling ore.

The cost of tires is important. Tire companies are manufacturing better tires. Mining companies are prolonging the life of tires by building better roads and maintaining correct tire pressure.

The trend is toward heavier equipment. In 1949 it cost $0.0925 a long ton to haul ore and waste with a 15-ton truck and $0.0743 a long ton with a 22-ton truck.

When trucks are properly maintained, hauling costs do not increase with the age of the trucks. During 1948 it cost $0.1118 per long ton to haul with the four oldest 15-ton trucks and $0.1130 per long ton to haul with the four newest 15-ton trucks, two of which were purchased in 1945 and two in 1947.

The weighted average cost of hauling a long ton of ore to the crusher and waste to the dump has been reduced from $0.1159 in 1948 to $0.087 in 1949.

The National Lead Co. has demonstrated that not withstanding rising wages and higher prices for supplies, more efficient haulage practices result in lower costs.

The Bureau of Mines and the mining companies that are cooperating with it in this investigation have the objective of developing information on truck haulage methods and costs for the benefit of all who are interested in the possible improvement of mining practices.

ACKNOWLEDGMENTS

The writer is indebted to the staff of the National Lead Co. for permission to publish the data contained in this information circular, and especially to Frank R. Milliken, assistant manager, Titanium Division; George W. Wunder, plant manager of the MacIntyre Development; Paul W. Allen, assistant plant manager; Charles Begor, Sr., mine superintendent; C. A. Quam, assistant mine superintendent; Charles Begor, Jr., maintenance superintendent; and John Zollinger, assistant maintenance superintendent, for their assistance and courtesy.

The investigation was under the general supervision of McHenry Mosier, chief, College Park Mining Branch, Mineral-Technology Division of the Bureau of Mines, Region VIII. The Regional Director, Region VIII, is Harold P. Greenwald, Pittsburgh, Pa.

LOCATION

The vanadium-bearing magnetite-ilmenite deposit is at Tahawus, Essex County, N. Y., on the east shore of Sanford Lake, which forms the headwaters of the Hudson River. It is in the heart of the Adirondack Mountains at an altitude of 1,800 feet, 32 miles by highway north of the village of North Creek. The mine is served by the Delaware & Hudson Railroad.

HISTORY

Archibald MacIntyre discovered iron ore in the Sanford Lake area in 1826. He founded the Adirondack Iron & Steel Co., which started to produce iron in 1838 but failed in 1858. The mine subsequently became the property of the MacIntyre Iron Co., which held it until 1941, when the National Lead Co. purchased the property and immediately started development. After completing 11,000 feet of diamond core-drilling to delineate the ore body, the company started open-cut mining. A 4,000 ton a day mill was erected south of Sanford Hill to process titaniferous magnetite ore and produce ilmenite concentrate and magnetite concentrate. An attractive modern village for the employees and their families was built by the company on the southeast shore of the lake. Production began in July 1942.

PHYSICAL FEATURES AND CLIMATE

Sanford Lake, altitude 1,720 feet, and Henderson Lake, altitude 1,810 feet, form the headwaters of the Hudson River. As the Weather Bureau station at Lake Placid, 17 miles north of Sanford Lake, has an altitude of 1,864 feet, which is the same as the mine, its records should conform closely to observations at Sanford Lake. The 50-year averages for Lake Placid are as follows: mean annual temperature, 39.3°F.; average maximum temperature, 50.2°F.; average minimum temperature, 28.6°F. The highest temperature ever recorded is 96°F. and lowest ever recorded -39°F. Average annual precipitation is 39.36 inches, which includes 129.1 inches of snow. The heaviest snowfall occurs in January, and the average is 25.8 inches.

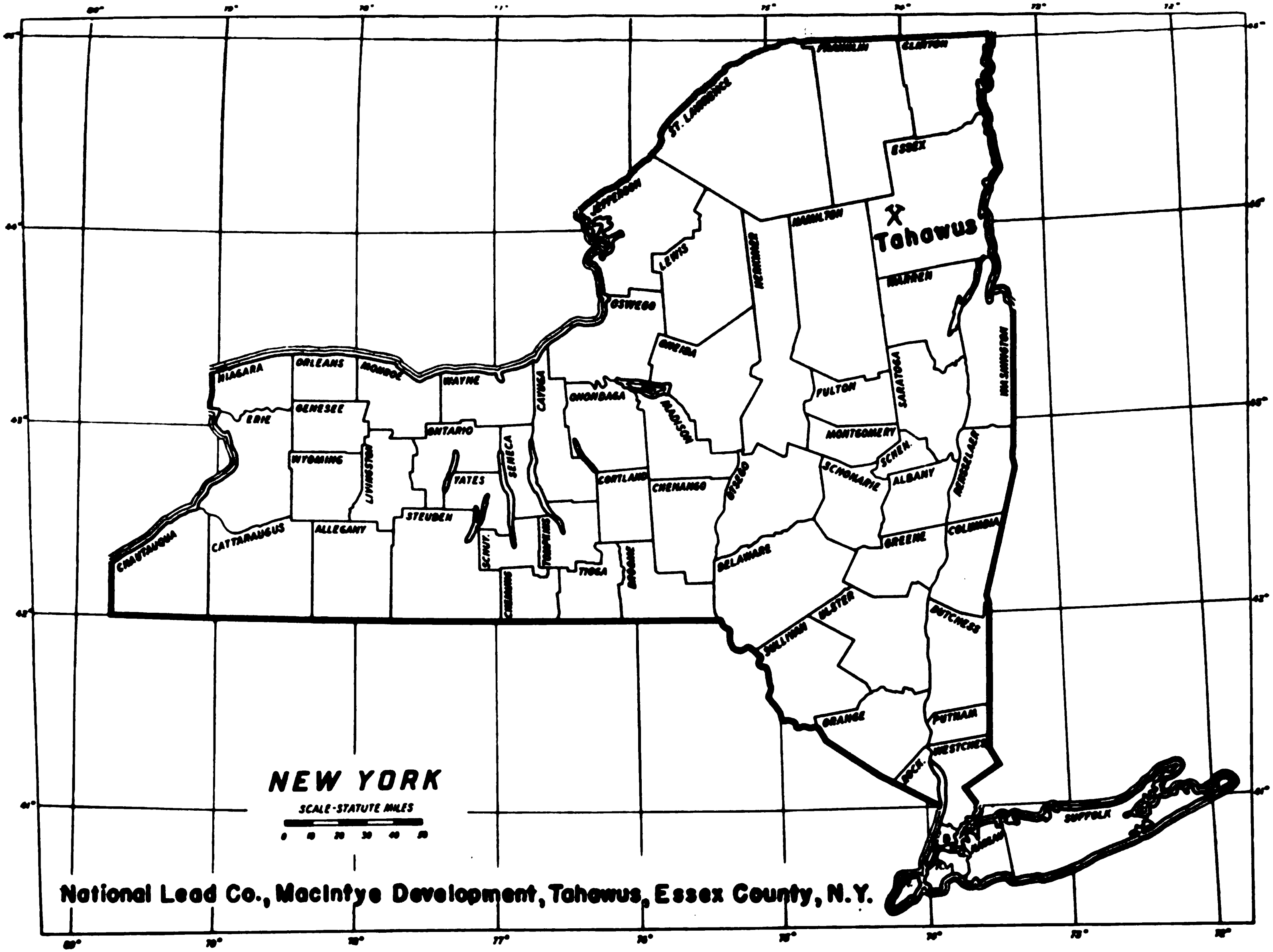

Figure 1. - Location map.

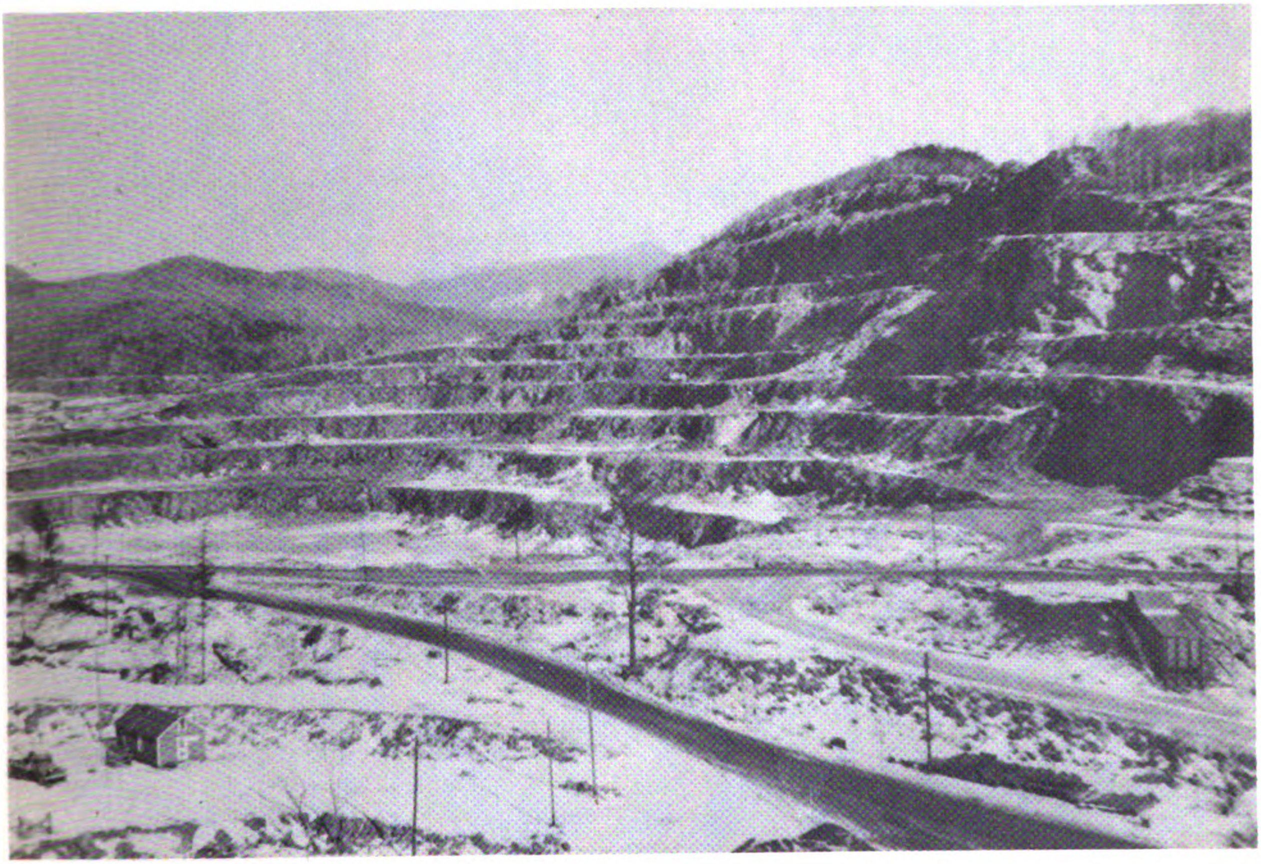

Figure 2. - Open-cut mine, MacIntyre Development, National Lead Co.

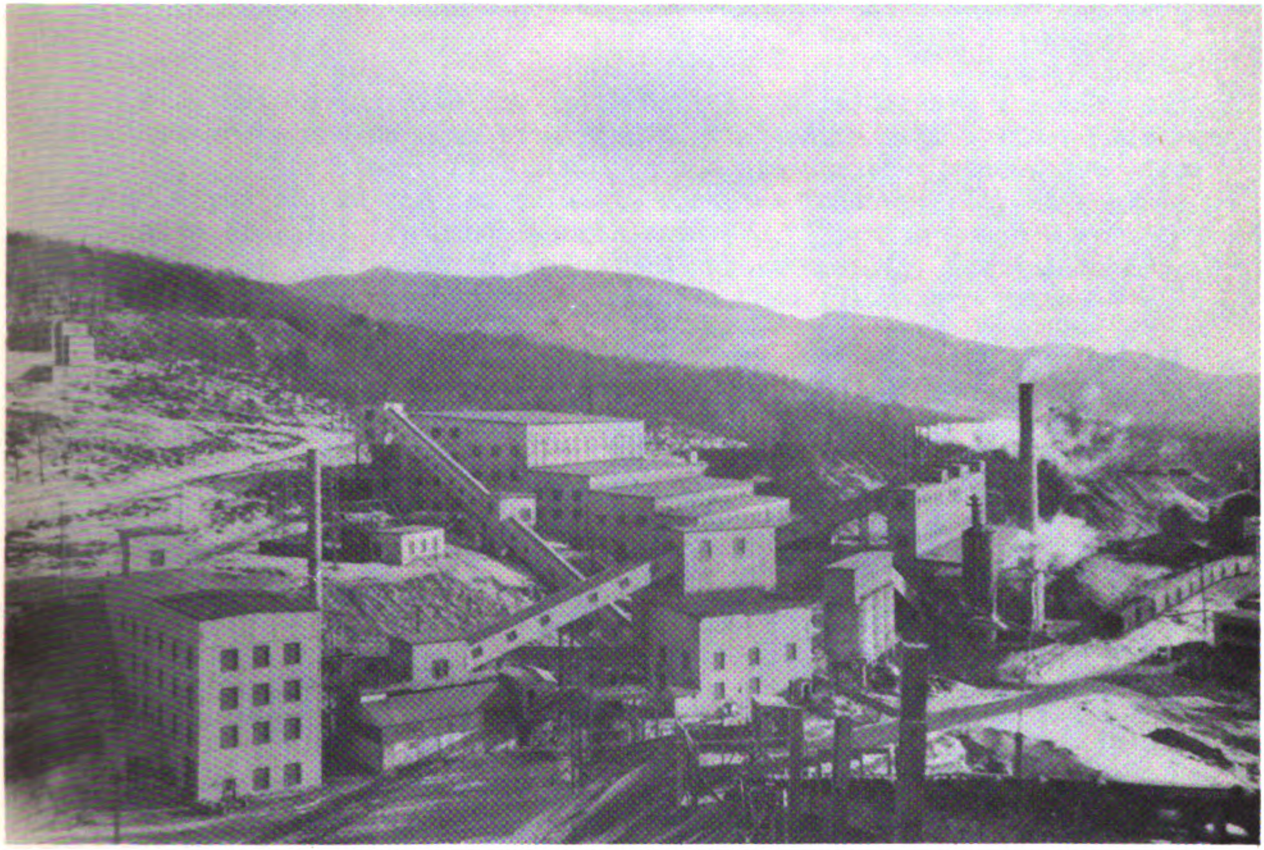

Figure 3. - The concentrator, MacIntyre Development, National Lead Co.

The company has made adequate preparation for cold weather and operates the mine (fig. 2), concentrator, and sintering plant throughout the year. (See fig. 3.)

CHARACTER OF ORE

The geology of the Adirondack Mountains has been discussed at length by Balk,2/ Alling,3/ and Buddington.4/ Briefly summarized, the oldest rocks belong to the Grenville series of metamorphosed sediments, successively intruded by (1) anorthositic and gabbroic rocks, (2) syenitic and granitic rocks, (3) diabase dikes, (4) granite and basalt dikes. The magnetite-ilmenite deposits now being mined are found in the anorthositic and gabbroic rocks.

The magnetite-ilmenite ore is thought to be related to the anorthosite and gabbro rocks and to have been formed by magmatic segregation. According to Milliken,5/ there are, from a mining and ore-dressing standpoint, five distinct types of ore and two of waste rock, as follows: (1) High-grade anorthosite ore, (2) low-grade anorthosite ore, (3) high-grade coarse-grained gabbro ore, (4) high-grade, fine-grained gabbro ore, (5) disseminated or low-grade gabbro ore, (6) anorthosite waste, and (7) gabbro waste.

The lenticular deposit at Sanford Hill is elliptical in plan, having a length approximately 1,800 feet and a maximum width of 900 feet. The dip ranges from 45° to 80° toward the west.

There are four known deposits of magnetite-ilmenite ore in the Sanford Lake area, namely, the Sanford Hill, Iron Mountain, Calamity Mill Pond, and Cheney Pond deposits.

MINING METHODS

The Sanford Hill ore body is favorably situated for open-cut mining. It is on the west side of Sanford Hill and dips toward Sanford Lake.

The open-cut mine has been developed along conventional lines by nine levels above and two levels below the elevation of the crusher. The trend conforming to modern practice has been toward heavier equipment. Table 1 is a list of the more important equipment.

2/ Balk, Robert, Structural Geology of the Adirondack Anorthosite: Min. Pet. Mitt., vol. 41, 1931, pp. 308-434.

3/ Alling, H. L., The Adirondack Anorthosite and Its Problems: Jour. Geol., vol. 40, 1932, pp. 193-237.

4/ Buddington, A. F., Adirondack Igneous Rocks and Their Metamorphism: Geol. Soc. America Mem. 7, 1939.

5/ Milliken, Frank R., Metallurgy of National Lead Co. MacIntyre Development: A.I.M.E. Mining Technology T.P. 2355, May 1948.

TABLE 1. - Equipment for open-cut mining

14	Diesel-powered end-dump trucks, 15-ton capacity.
3	Diesel-powered end-dump trucks, 22-ton capacity.
2	Electric shovels, 2-1/2 cu. yd. capacity.
1	Diesel shovel, 2-1/2 cu. yd. capacity.
1	Electric shovel, 4 cu. yd. capacity.
1	Motor road grader.
4	Crawler-type tractors.
1	Sprinkler truck in summer converted to a snow plow in winter.
1	Service truck for fuel oil, water, and drill bits.
1	Service truck for village, dynamite, etc.
2	Trucks for supervision.
1	Electric and gas welding outfit mounted on a trailer, ready to go to any repair job at a moment's notice.
5	Churn drills, crawler-mounted, electric power, 9-inch bit diameter.
1	Wagon drill.

Drilling and blasting methods have been described in detail[6] in the technical literature.

An electric salt-bath furnace for treating churn-drill bits in the hardening operation was installed by the company over a year ago. The average footage drilled by the churn-drill bits has increased 50 percent and the drilling speed 12 percent.[7]

The sludge from all churn-drill blast holes is sampled and assayed to assist in the control of feed to the mill.

During the war the emphasis was on mining ore, and because of personnel and equipment shortages, waste stripping could not be maintained at the correct ratio. After the war a contractor was employed and the stripping was brought up to schedule. At present, all ore mining and waste stripping is done with company-owned equipment. The shovels and drills are shown in figure 4.

TRUCK HAULAGE

Ore is hauled to the crusher and waste to the dumps in fourteen 15-ton and three 22-ton Diesel-powered end-dump trucks. The following factors contribute to efficient low-cost truck haulage: (1) good trucks correctly designed for heavy loads and the impact of loading with power shovels; (2) good truck maintenance and an efficient repair shop; (3) smooth roads adequately maintained; (4) well-trained, careful truck drivers.

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[6] Begor, C. R., and Quam, C. A., Drilling and Blasting at Tahawus: Mining Cong. Jour., vol. 34, No. 8, August 1948, p. 24.

[7] Quam, Carrol A., Salt-Bath Hardening Increases Churn-Drill Bit Life: Min. Eng., vol. I, No. 11, Nov. 1949, p. 38.

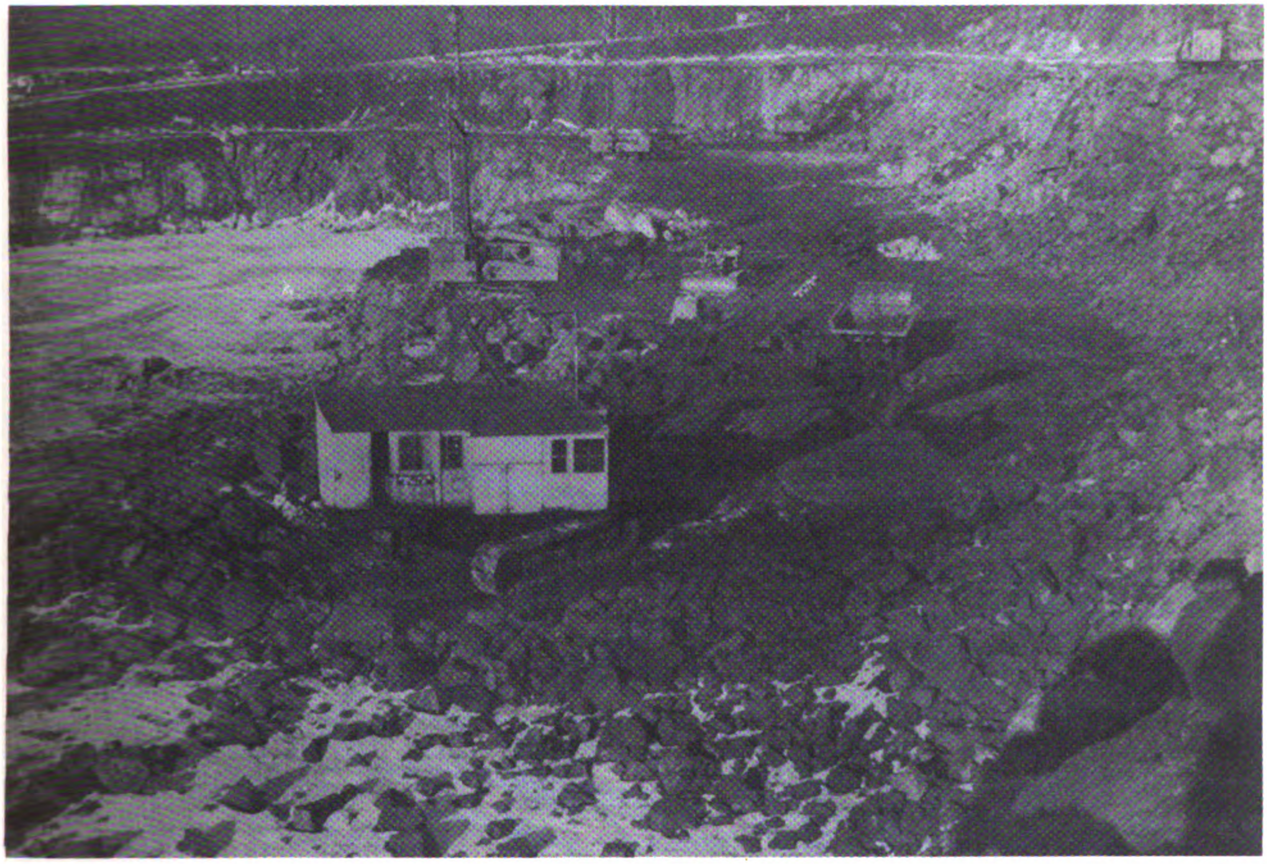

Figure 4. - View of shovels and drills, MacIntyre Development, National Lead Co.

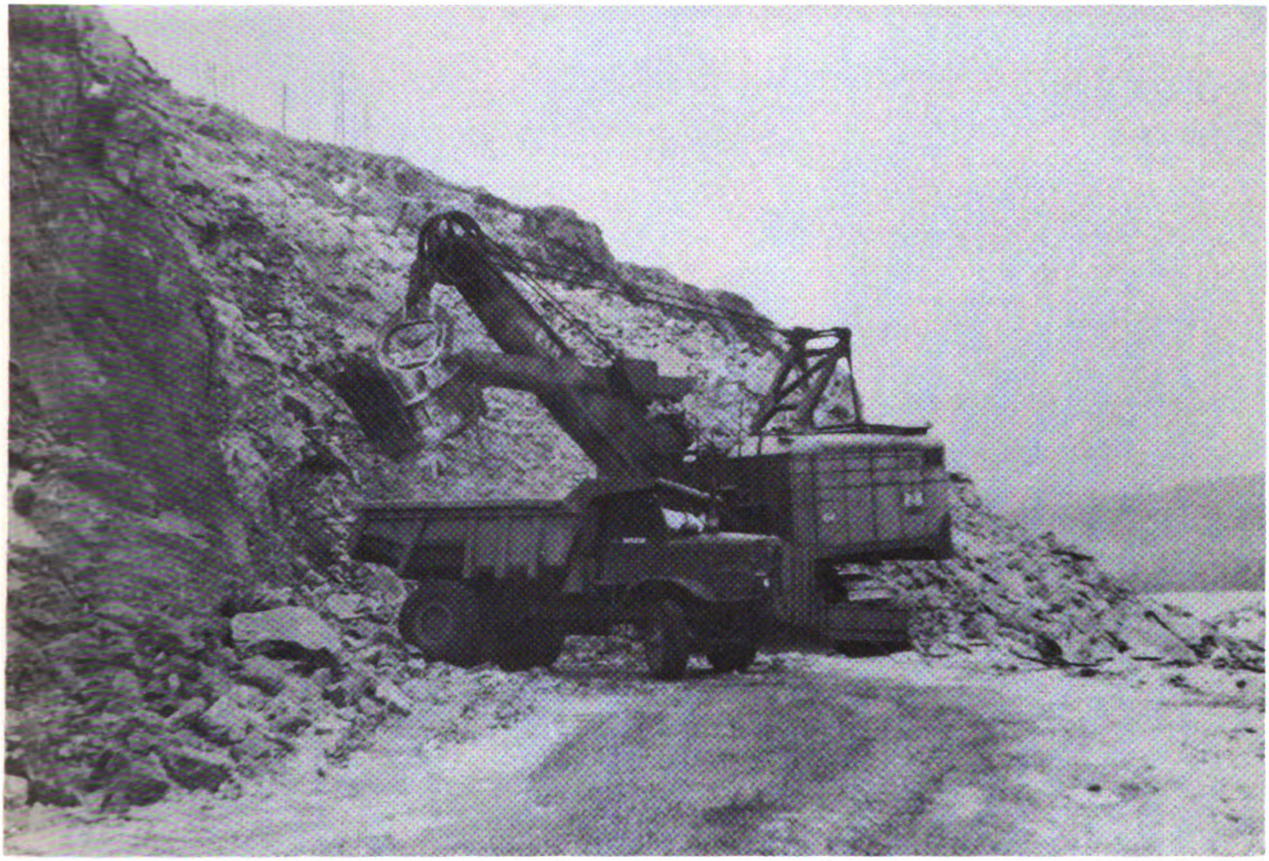

Figure 5. - Loading a 22-ton ore truck, MacIntyre Development, National Lead Co.

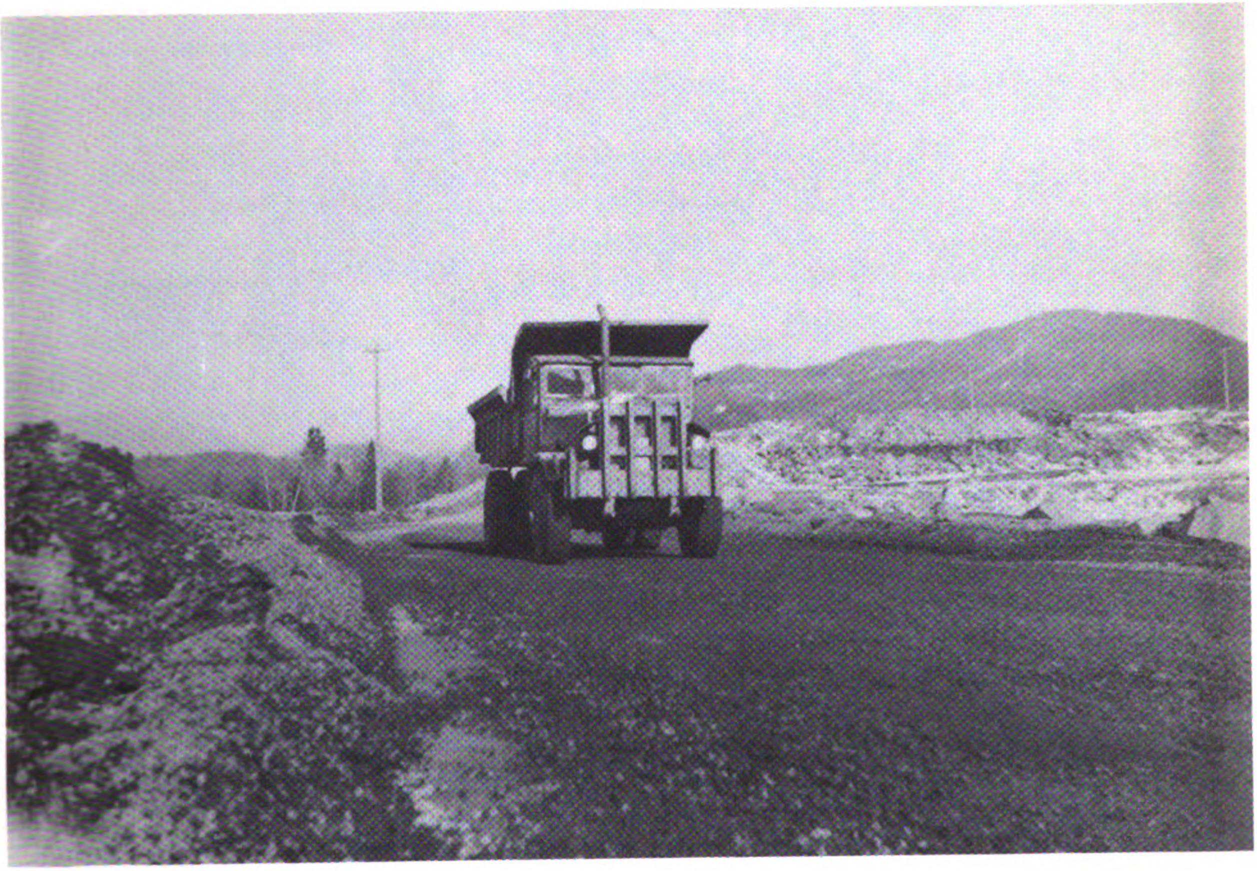

Figure 6. - Hauling ore on a smooth mine road, MacIntyre Development, National Lead Co.

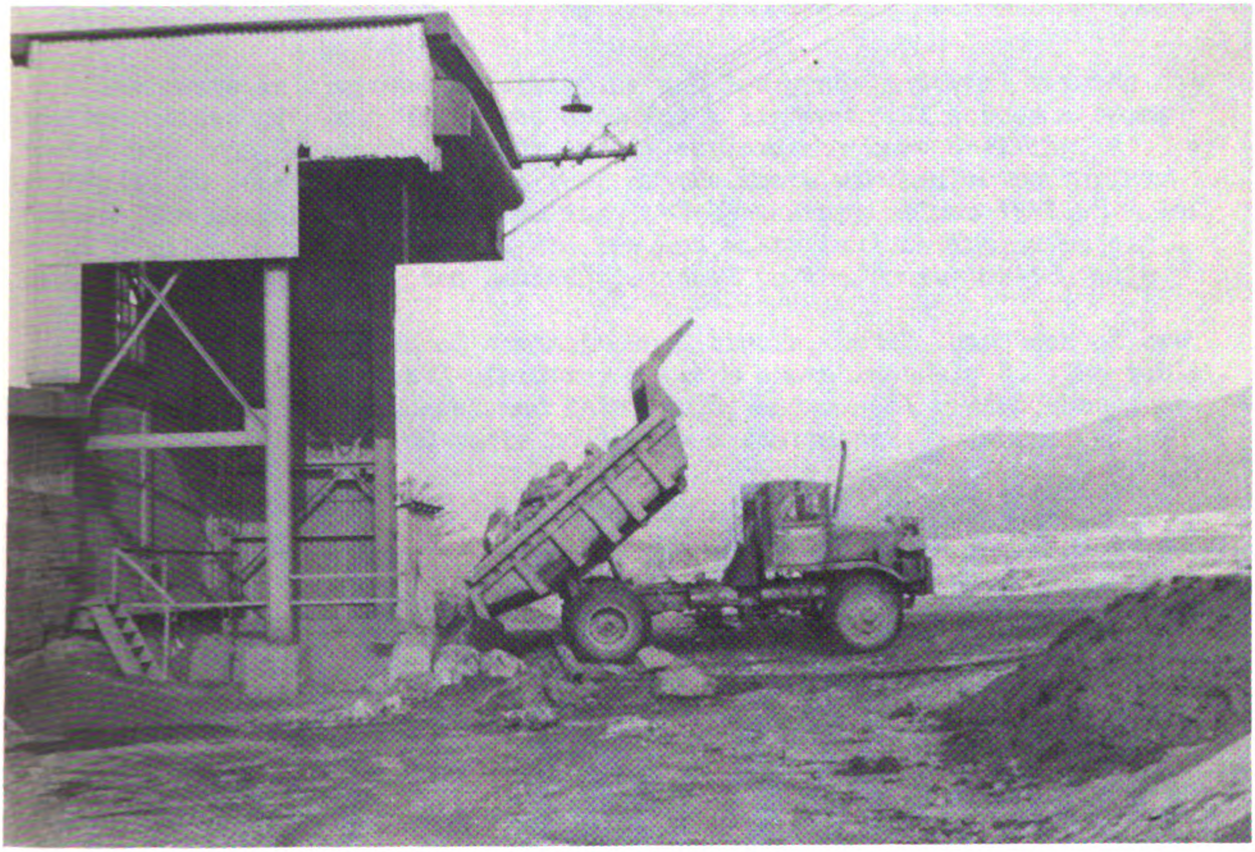

Figure 7. - Ore truck dumping at the crusher, MacIntyre Development, National Lead Co.

During 1949 an ore stock pile was created. Whenever two trucks were waiting at the crusher, the next truck dumped the ore on a nearby stock pile. After 15,000 tons had been accumulated on the stock pile, all except one of the mine shovels were assigned to waste stripping, and mill feed was loaded from the stock pile and hauled to the mill. The cost of this loading was added to the total truck operating cost, and no credit was taken for the tonnage hauled. This stock pile reduced the number of operating trucks and increased the over-all truck and shovel efficiency.

The trucks deliver the ore to a hopper above the primary 48- by 60-inch jaw crusher. The average ore haul is about 0.8 mile, or 1.6 miles a round trip. To date, most of the ore has been hauled downgrade. To facilitate downgrade hauling, six trucks were equipped with water-cooled brakes. The water-cooled brakes functioned very well when new, but maintenance was very costly.

The waste is composed of stripping and low-grade material between the concentrations of ore. Waste was used for a highway fill across a swamp toward the Iron Mountain ore body, where exploratory core drilling is scheduled to start in 1950. The rest of the waste was hauled to various dumps. The average waste haul during 1948-49 was approximately 1.25 miles, or 2.50 miles a round trip. As the ore and waste haul is approximately 1 mile, the "cost per long ton hauled" is equal to the "cost per ton mile."

The date of purchase of company-owned trucks, total long tons of ore and waste hauled, and total operating hours is shown in table 2. The table includes two trucks purchased and later sold, and rental trucks, but does not list the total ore and waste hauled by a contractor.

TABLE 2. - Truck tonnage report, 1942 through 1949

Truck no.	Date purchased, month-day-year	Total ore and waste, long tons	Total hours operated
1	10-31-41	927,750	22,107.5
2	10-31-41	926,818	21,407.0
3	10-31-41	1,025,530	22,817.5
4	10-31-41	1,059,697	26,383.5
5	12-31-45	694,541	15,262.5
6	12-31-45	706,515	15,184.0
7	12-? -42	1,097,550	25,103.0
8	12-? -42	974,251	22,440.0
9	6-29-44	811,116	17,705.0
10	6-29-44	816,993	18,100.0
11	12-? -45	694,848	15,357.0
12	12-? -45	695,715	15,048.5
13	6-30-47	507,194	10,615.0
14	6-30-47	479,864	10,001.0
15	2-9-48	586,662	7,096.0
16	2-9-48	597,352	7,194.0
17	2-9-48	605,356	7,428.0
5-A	Sold	387,149	7,979.0
60A	Sold	484,596	8,400.0
Service #7 in '42		8,372	
Rentals in '44		40,624	
		14,128,493	295,630.5

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Trucks 1 to 14, inclusive, are 15-ton capacity, and 15 to 17, inclusive, are 22-ton capacity.

The cost of hauling ore to the mill and waste to the dump is shown in table 3.

TABLE 3. - Hauling costs

Year	Total cost	Total long tons, ore and waste	Cost per long ton, ore and waste
1943	$100,109.58	1,168,685	$0.09
1944	154,546.84	1,272,442	0.12
1945	166,993.06	1,553,517	0.11
1946	143,446.15	1,634,281	0.09
1947	190,212.94	1,766,015	0.108
1948	355,166.67	3,064,018	0.1159
1949	271,035.47	3,115,314	0.0870

Cost-accounting methods have been improved, and detailed costs on each truck are now available, as shown in table 4:

TABLE 4. - Direct operating cost for trucks in 1948

Truck no.	Direct operating labor	Fuel oil	Labor	Material	Tools and supplies	Depreciation	Insurance	Income (credit)	Crane and factory cartage	Total cost	Cost per ton	Total long tons hauled	Hours operated
1 ...	$4,700.08	$665.83	$3,061.86	$6,682.52	$470.97	*0.81	$74.05	*300.30	0.60	$15,354.80	$0.108	142,593	2,794.5
2 ...	4,011.88	693.68	2,804.75	7,323.28	469.67	*.73	74.05	*174.72	2.36	15,204.22	.132	115.376	2,421.0
3 ...	5,106.82	745.22	3,080.88	8,746.00	531.51	*.20	65.82	*382.20	1.16	17,895.01	.108	165,511	3,175.5
4 ...	4,804.34	690.29	3,120.40	6,094.43	480.77	.04	71.09	*129.19	4.34	15,136.51	.104	145,326	2,979.0
5 ...	6,758.30	1,035.52	3,374.63	9,709.61	785.41	1,977.22	94.07	*276.88	8.13	23,466.07	.124	189,743	4,094.0
6 ...	5,953.01	925.25	3,352.23	11,045.43	662.62	2,156.82	79.81	*546.00	1.25	23,630.42	.146	161,668	3,658.5
7 ...	5,538.22	790.30	3,489.00	8,011.19	554.44	*.54	66.11	*447.72	.46	18,001.46	.109	165,693	3,331.5
8 ...	5,221.15	695.71	3,234.62	7,737.62	420.69	*.44	66.11	*382.20	6.84	17,000.10	.113	150,669	3,179.5
9 ...	4,681.46	649.81	3,014.53	7,334.13	470.99	1,312.77	66.27	*131.04	10.52	17,409.44	.132	131,832	2,749.0
10 ...	3,067.38	531.74	2,619.15	5,097.38	384.15	1,314.20	60.61	*374.89	36.46	12,736.18	.147	86,726	1,979.0
11 ...	6,235.70	942.83	3,570.94	8,841.73	638.64	2,157.18	79.85	*127.56	29.64	22,368.95	.123	174,321	3,642.5
12 ...	6,823.16	940.21	3,168.59	10,001.47	666.38	2,157.05	79.85	*144.64	2.72	23,694.79	.120	196,648	4,243.5
13 ...	6,899.65	1,102.28	3,420.93	10,536.77	778.52	5,238.08	101.47	*86.80	1.47	27,992.37	.145	193,324	4,292.5
14 ...	6,824.22	1,058.08	3,451.03	9,018.38	737.65	5,238.14	101.47	*21.84	1.36	26,408.49	.136	194,157	4,293.5
15 ...	5,836.01	1,014.64	2,576.43	7,925.46	874.01	7,571.43	113.88	*65.52	2.46	25,848.85	.091	284,506	3,635.0
16 ...	5,948.11	993.73	2,650.22	7,546.13	738.01	7,571.24	113.88	*43.68	27.10	25,544.70	.088	288,907	3,695.5
17 ...	5,761.55	991.99	2,905.35	9,398.86	773.84	7,571.98	113.88	*65.52	22.40	27,474.33	.099	277,018	3,678.0
	94,171.04	14,467.11	52,895.59	141,050.39	10,438.27	44,263.43	1,422.27	*3,700.70	159.27	355,166.67	.116	3,064,018	58,087.0

*Indicates a credit.

The 1949 total truck operating and repair costs, tons of ore and waste hauled, cost per ton, and hours operated are as follows:

TABLE 5. - Truck operating data, 1949

Truck no.	Total operating and repair cost	Long tons Ore	Long tons Waste	Long tons Total	Cost per ton	Hours operated
1	$8,276.59	35,091	47,050	82,141	$0.100	1,567.0
2	7,663.54	25,121	33,225	58,346	.131	1,087.0
3	8,305.66	43,334	44,487	87,821	.095	1,586.0
4	9,846.22	35,086	46,990	82,076	.120	1,568.0
5	17,236.71	104,950	79,777	184,727	.093	3,418.5
6	16,930.00	143,431	64,682	208,113	.081	3,322.5
7	13,560.94	92,884	69,601	162,485	.084	2,953.5
8	14,126.98	95,638	59,811	155,449	.091	2,806.0
9	12,659.25	71,671	74,949	146,620	.086	2,746.0
10	17,308.66	117,633	64,987	182,620	.095	3,325.0
11	19,287.93	125,059	70,589	195,648	.099	3,042.5
12	17,910.53	132,257	80,736	212,993	.084	3,456.0
13	19,244.46	135,712	85,129	220,841	.087	4,031.5
14	18,866.14	131,855	64,640	196,495	.096	3,519.5
15	22,668.05	14,124	288,032	302,156	.075	3,461.0
16	23,055.55	10,224	298,221	308,445	.075	3,498.0
17	24,088.26	14,286	314,052	328,338	.074	3,750.0
Contractor		648	4,371	5,019		
	271,035.47	1,329,004	1,791,329	3,120,333	1/0.0870	49,138.0

1/ Cost per ton calculated on tons hauled by company-owned truck exclusive of the 5,019 tons hauled on contract.

A comparison of truck operating costs for 1948 and 1949 is as follows:

TABLE 6. - Comparison of truck operating costs

Item	1948			1949		
	Total amount	Cost per long ton	Cost per operating hour	Total amount	Cost per long ton	Cost per operating hour
Direct operating labor	$94,171.04	$0.0307	$1.621	$78,851.77	$0.0253	$1.605
Fuel oil	14,467.11	.0047	.249	12,387.68	.0040	.252
Truck repair labor	52,895.59	.0173	.911	38,162.94	.0123	.777
Truck repair material	141,050.39	.0460	2.428	95,928.70	.0308	1.952
Tools and supplies	10,438.27	.0034	.180	6,385.32	.0020	.130
Depreciation ...	44,263.43	.0144	.762	2/		

TABLE 6. - Comparison of truck operating costs (Cont'd.)

Item	1948			1949		
	Total amount	Cost per long ton	Cost per operating hour	Total amount	Cost per long ton	Cost per operating hour
Insurance	$1,422.27	$0.0005	$0.024	$1,908.61	$0.0006	$0.039
Income (credit)	-3,700.70	-.0012	-.064	-833.73	-.0003	-.017
Factory cartage	159.27	.0001	.003			
Other expense .				31,960.34	.0103	.650
Extra compensation1/				6,283.84	.0020	.128
Total cost	355,166.67	.1159	6.114	271,035.47	.0870	5.516
Total tons hauled	3,064,018			3/3,115,314		
Total hours operated	58,087.0			49,138.0		

1/ Extra compensation is employees' Christmas bonus.
2/ Depreciation included in Other Expense in 1949.
3/ Does not include 5,019 tons hauled on contract.

The over-all cost of hauling ore and waste was considerably lower in 1949 than it was in 1948. Truck maintenance was much lower, due partly to the fact that more engines were overhauled in 1948 than 1949. The haulage efficiency was increased 20.3 percent. It was 52.7 tons per hour in 1948 and 63.4 tons per hour in 1949.

Mine roads were maintained in better condition by using more crushed-stone road surfacing and employing a full-time road-grader operator. In the summer when the roads are dry and dusty a sprinkler truck operates full time.

Very little operating time was lost due to equipment repairs after the mine went to a 5-day week, Monday through Friday. All of the maintenance men and repairmen worked on Saturday.

The labor turnover since the end of the war has been almost nil. As the truck drivers gained more experience, accidents were fewer and maintenance costs lower.

A comparison between 22-ton and 15-ton Diesel trucks is shown in the following table.

TABLE 7. - Comparison of operating data and costs, 22-ton and 15-ton trucks

	1948		1949	
	22-ton[1]	15-ton	22-ton	15-ton
Total operating cost	$78,867.88	$276,298.79	$69,811.86	$201,223.61
Total hours operated	11,008.5	47,078.5	10,709.50	38,428.5
Cost per hour	$7.15	$5.87	$6.52	$5.24
Tons per hour	77.3	27.0	87.7	56.6
Average hours per month per truck	333.6	280.5	297.5	228.7
Cost per ton	$0.0927	$0.1248	$0.0743	$0.0925
Total tons hauled	850,431	2,213,587	938,939	2,176,375

[1] Data for 11 months.

The policy of maintaining the trucks in excellent condition is reflected in table 8. The cost per ton for hauling has not increased with age. The four oldest 15-ton trucks, purchased in 1941, are compared with the four newest 15-ton trucks. Trucks 11 and 12 were purchased in December 1945, and trucks 13 and 14 were purchased in June, 1947.

TABLE 8. - Comparative costs, old and new trucks

Trucks	Total operating and repair cost, without depreciation	Total long tons hauled	Cost per long tons hauled
1, 2, 3, 4	$63,588.84	568,806	$0.1118
11, 12, 13, 14 ...	85,674.15	758,450	0.1130

Depreciation was deducted to keep the comparison on the same basis. The old trucks operated fewer hours and hauled fewer tons because they have manual steering. The drivers prefer the new trucks with hydraulic power steering.

Tires

The cost of truck tires is a major item in the total cost of hauling ore and waste. It is generally recognized that heavy-duty tires on ore trucks do not wear out but usually fail because of stone bruises, that occur at the shovel or on the waste dump during the night shift. Bulldozers are kept near the shovels and waste dumps to clean the roads and keep them smooth. Even so, stone bruises do occur, so that the average life of a tire is approximately 7,000 miles. The company builds good mine roads and maintains them in excellent condition with a motor grader and sprinkler truck.

Tire chains are not used on the ore trucks. Calcium chloride sprinkled on the ice and snow has proved effective.

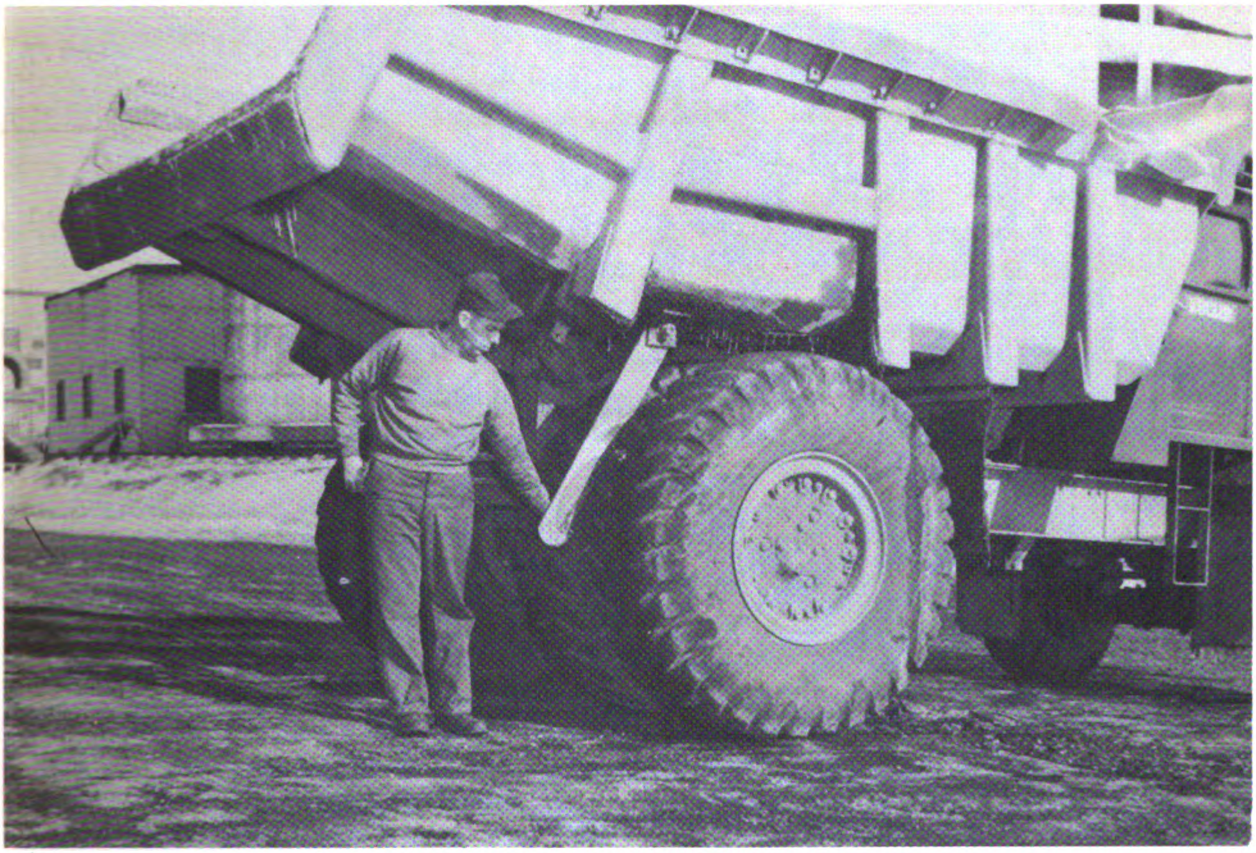

Figure 8. - Steel plate hung between dual tires to keep rocks from wedging between the tires, MacIntyre Development, National Lead Co.

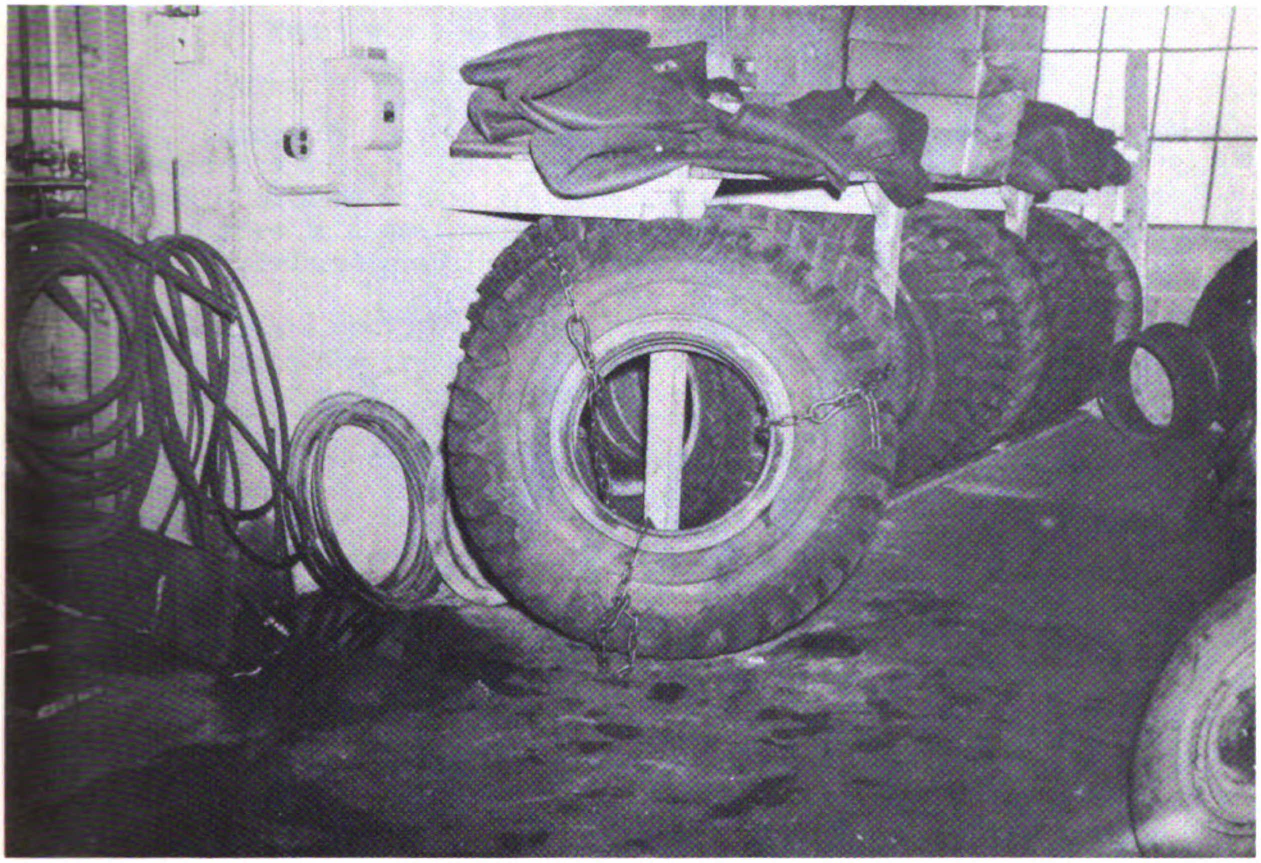

Figure 9. - Safety chains used when tires are being inflated for the first time, MacIntyre Development, National Lead Co.

The 15- and 22-ton trucks are equipped as follows:

Tire sizes and costs

	Tire size	Cost	
		Tires	Tubes
15-ton truck:			
Front tires	13x24	$235	$18
Rear dual tires	14x24	280	23
22-ton truck:			
Front tires	14x24	280	23
Rear dual tires	18x24	546	47

It is important that tires be inflated to the exact pressure recommended by the manufacturer. In order to obtain maximum wear, the diameter of dual tires must be matched within 1/4 inch. A new tire should never be installed with a used tire in a dual mount. To prevent rust, the rims are painted with a mixture of powdered graphite and brake fluid.

A steel plate, 0.75 by 5 inches in cross section and 4 feet in length is suspended from the truck frame between the dual tires. The plate will remove a rock before it becomes wedged between the dual tires. (See fig. 8.)

Accidents have occurred when heavy-duty truck tires are inflated for the first time, because a lock rim may blow off and injure the tire-repair man. To prevent this type of accident, three safety chains are placed around the tire and rim before the initial inflation. (See fig. 9.)

A study of tire costs was conducted April 25 to August 1, 1949, as follows:

TABLE 9. - Tire costs and mileage

	Number of new tires	Cost of new tires	New tire mileage	Number of repairs	Cost of repairs	Mileage after repairs	Total cost	Total mileage
Manufacturer #1								
Size 13 x 24 in.	8	$1,872.49	62,459	3	$154.10	11,790	$2,026.59	74,249
Average mileage			7,807			3,930		9,281
Av. cost per mile		0.030			0.013		0.027	
Size 14 x 24 in.	13	3,639.24	65,874	4	242.82	8,846	3,882.06	74,720
Average mileage			5,067			2,212		5,747
Av. cost per mile		0.055			0.027		0.052	
Manufacturer #2								
Size 13 x 24 in.	4	906.46	31,702	1	33.00	555	939.46	32,257
Average mileage			7,925			555		8,064
Av. cost per mile		0.029			0.059		0.029	
Size 14 x 24 in.	6	1,654.86	16,365	3	130.70	3,945	1,785.56	20,310
Average mileage			2,727					3,385
Av. cost per mile		0.101			0.033		0.088	
Manufacturer #3								
Size 14 x 24 in.	4	1,089.24	27,874	1	166.69	623	1,255.93	28,497
Average mileage			6,969			623		7,124
Av. cost per mile		0.039			0.268		0.044	

Total cost of 35 tires worn out and scrapped	$9,889.60
Total miles	230,033
Average miles per tire	6,572
Average cost per mile per tire	$0.043

Maintenance

The garage mechanics work three shifts a day. The major repair jobs are done on day shift. After the day shift in the mine, the fuel oil, lubricating oil, and water in each truck are checked. After the night shift, all the trucks are refueled. Air pressure in all tires is checked and is held within 5 pounds of that recommended by the tire manufacturer.

The trucks are given a regular, complete service every 60 to 80 operating hours. Each day the two trucks with the most operating hours are serviced as follows: (1) grease chassis, (2) change engine oil, (3) check air filter (during the summer the oil bath may have to be changed and the filter cleaned every week, but when snow is on the ground it is changed every two or three months); (4) add battery water as needed, (5) inspect for loose or missing bolts, (6) inspect lights, (7) test windshield wiper, (8) test brakes, (9) inspect truck frame, and (10) inspect truck body.

According to the maintenance superintendent, a good lubrication man is the most important employee on the job. He not only lubricates the truck but also finds the repair jobs that are needed before a breakdown occurs.

The Diesel truck engines are overhauled or rebuilt when the bearings and pistons show excessive wear and use an excessive amount of lubricating oil. This occurs about every 2 years, or after 7,000 to 10,000 operating hours. Rebuilding a Diesel truck engine costs about $2,000.

The truck bodies as received from the factory required additional reinforcing to withstand the impact of loading magnetite-ilmenite ore, because the ore is unusually heavy, hard, and abrasive. The first experiment was to weld 4 x 4 x 1/2-inch angle irons on the bottom, sides, and protective canopy. The impact of the ore had a tendency to flatten the angle irons in the bottom of the truck body; excessive maintenance was required. Angles are no longer used in the bottom of the body, but angles are still welded on the sides and canopy. The next experiment was to cover the bottom of the body with a 5/8-inch mild-steel plate. This plate gave the required strength but had a tendency to wear thin. Later, 1-inch manganese steel strips 6 inches wide, spaced 4 inches apart, were bent to conform to the waves in the bottom of the truck bottom and were welded to the 5/8-inch plate. An experiment is now being conducted on one truck with 1/2- by 6-inch alloy steel strip containing alloying material as follows: 1.35 to 1.65 percent manganese, a maximum of 0.04 percent phosphorus, a maximum of 0.04 percent sulfur, 0.15 to 0.30 percent SiO_2, and 0.10 to 0.20 percent molybdenum.

The cost of Diesel fuel and lubricating oil is as follows:

	Cost, without tax, per gallon	
	1948	1949
Diesel fuel oil	$0.115	$0.1068
Diesel lubricating oil	0.56	0.56

As a check on driver and truck performance, all trucks are equipped with a tachograph. A description of the operation and functions is given below: (1) The signal light at the lower right-hand corner of the tachograph gives a warning to the driver that he is exceeding the specified r.p.m. limit. (2) The chart provides a permanent record as follows: (a) Truck operations for the entire day, (b) the total revolutions of the engine, (c) the accurate r.p.m. of the motor at any time of the day, (d) the exact time the truck was in motion. This record is made independently of the other data even if the drive cable should be broken or disconnected. (See fig. 10.)

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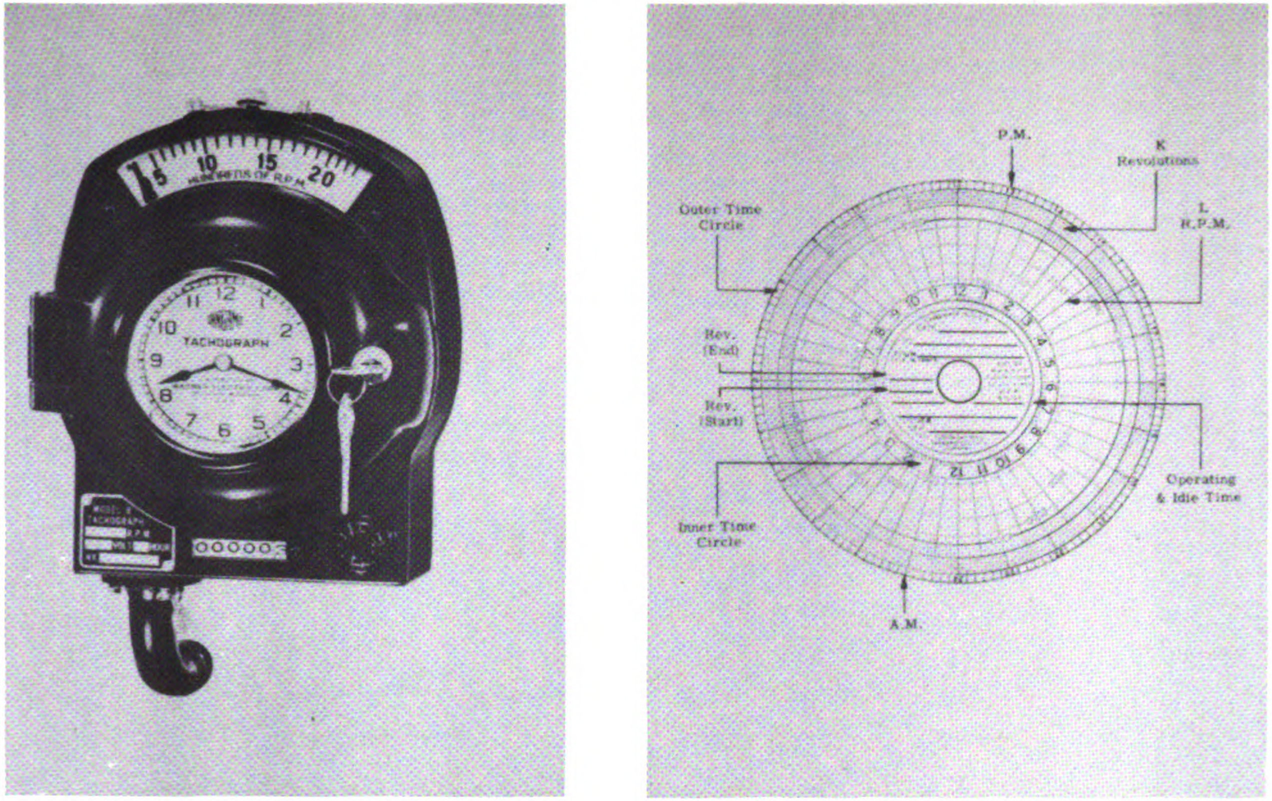

Figure 10. - The tachograph and recording chart.